action of small doses of strophanthin on the cardiac nervous mechanism of that animal.

The lengthening out of the systole in veratrine poisoning corresponds to the same well-known lengthening of the systole in the frog's heart under veratrine. The reversing of rhythm observed in morphine poisoning is similar to that mentioned by Ludwig* as occurring in the mammalian ventricle when under the influence of opium, for then the auricular beats follow instead of precede the ventricular beats, the rhythm being reversed. The same occurs in amyl nitrite poisoning.

Krukenberg† has stated that neither atropine nor muscarine affects the heart of Ascidians.

My observations on the action of atropine and muscarine, which have been made on a large number of embryos, show that in the absence of a nervous mechanism they do not influence the heart. This will probably modify the current views on the action of these drugs, and my results show that the method I have adopted is a valuable one for differentiating the functions of cardiac muscle from those of the nerves which supply it.

II. "Further Researches in Connexion with the Metallurgy of Bismuth." By Edward Matthey, F.S.A., F.C.S., Assoc. Roy. Sch. Mines. Communicated by Sir G. G. Stokes, Bart., F.R.S. Received November 21, 1892.

In 1886–87 and in 1890 I submitted papers to the Royal Society bringing under notice facts which had come to my knowledge whilst engaged upon the practical extraction of this beautiful metal from its ores, and in its separation from impurities which are always associated with it when in a crude or unrefined state.

IV. *Bismuth, its Separation from Arsenic.*

In a paper dated February 10, 1887,‡ allusion is made to the fact that arsenic is often one of these impurities, and at the same time a method is given by which the separation of this metal from bismuth was then successfully effected.

The process adopted when that paper was read, and for a considerable period subsequently, when working upon bismuth containing arsenic, consisted in removing the arsenic by fusing the arsenical

* Ludwig, 'Lehrbuch der Physiol. des Menschen,' Bd. 2 (1861), p. 38.

† Krukenberg, quoted in Brunton's 'Text-Book of Pharmacology,' &c. (3rd edition, p. 114).

‡ 'Proc. Roy. Soc.,' vol. 49.

bismuth in contact with metallic iron at a dull-red heat and under flux. A compound of iron and arsenic was thus formed and could be removed as a scum; the disadvantages of this process being, 1st, loss of bismuth by volatilisation, and, 2ndly, much loss of time in the manipulation of any large quantity to be treated.

Having occasion, a few months ago, to melt together a large quantity of arsenical bismuth, some 700 or 800 kilos., that is, more than three quarters of a ton, in order to obtain a homogeneous alloy upon which to work subsequently by the process above alluded to, it became evident that when the temperature was raised above the melting point of bismuth, the surface of the metal being exposed to the atmosphere, arsenical fumes appeared, and that these increased as the temperature of the metal became more elevated, the result being that the arsenic came off in dense white fumes (As_2O_3).

The observation of this fact led to further experiments, and it was found that if the surface of the bath of fused arsenical bismuth was freely exposed to the air at a temperature rather higher than its own melting point, and if the molten metal was constantly stirred, it was possible to eliminate the whole of the arsenic alloyed with the bismuth by this simple process of fusion with stirring.

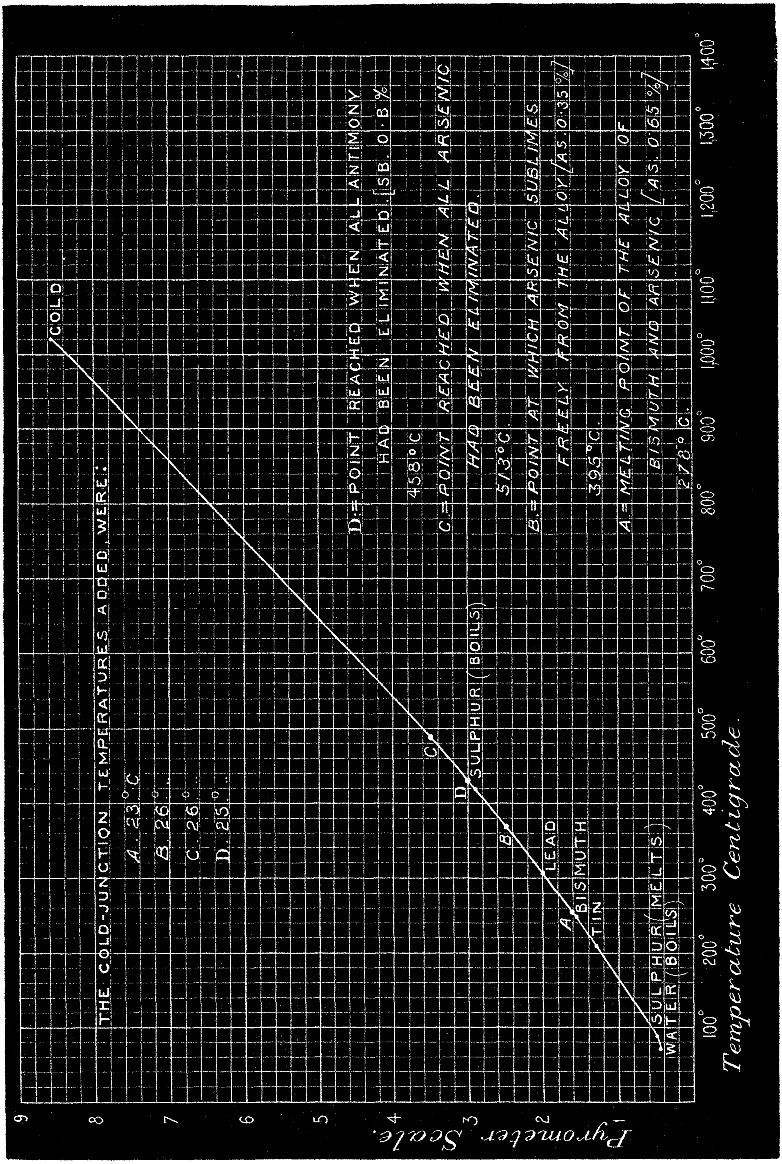
As it is a matter of considerable interest for metallurgists to know, not only that this elimination does take place, but also at what temperature it occurs, a series of experiments have been conducted with a view of determining this accurately.

The work of Roberts-Austen has shown that a thermo-junction is practically the only form of pyrometer that can be used for delicate thermal investigations of this kind, but the question arose which particular thermo-junction should be adopted. Was it well to use the platinum-iridium one as advocated by Barus, or the platinum-rhodium one suggested by H. Le Chatelier? My previous work on the alloys of platinum and rhodium, lately published in the 'Philosophical Transactions,' settled the question in favour of the rhodium-platinum thermo-junction, for I was satisfied that the alloy of platinum with 10 per cent. of rhodium is as homogeneous as any known alloy could well be, and is therefore admirably adapted for use as a thermo-junction, pure platinum being the opposing metal.

The diagram shows the results obtained by calibrating the thermo-junction by the aid of certain known melting points. The temperature at which arsenic is eliminated is also shown on the diagram.

Analysis proved that the alloy operated upon in these experiments contained 0·65 per cent. of metallic arsenic.

From the diagram it will be seen that the melting point of this alloy of bismuth is 278° C. By raising the temperature of the alloy to 395° C. the arsenic freely sublimates from the bismuth alloy, and at a temperature of 513° C. the whole of the arsenic is eliminated.



A point of much interest in relation to molecular physics became evident in the course of the investigation. Arsenic, as is well known, volatilises at the comparatively low temperature of 180° C., without passing through the molten state. Arsenic is not, however,

given off freely from the arsenical bismuth until a temperature of 395° is reached. So that the temperature of disassociation of this alloy, containing 0·65 per cent. of arsenic, is 114° C. higher than the melting point of the mass. It was interesting to determine at what temperature the arsenic would be evolved if the alloy were heated *in vacuo*.

A portion of the bismuth alloy containing 0·65 per cent. of arsenic was introduced into a hard glass tube, slightly depressed to its centre, and connected at one end with a Sprengel pump, by which it could be rendered vacuous.

The pyrometric wires were in contact with the metallic alloy and passed to the galvanometer through the opposite sealed end of the glass tube.

Heat being applied, the first indication of the volatilisation of the arsenic, shown by the condensation of a film on the cool part of the tube, occurred at 275° C. When the alloy was quite melted the temperature indicated was 316° C.; arsenic came off freely when the temperature rose to 569° C., condensing in a black mirror.

The metal was then allowed to cool, and its setting point was found to be 268° C., which corresponds with that of the melting point of bismuth.

The bulk of the arsenic does not appear to be evolved *in vacuo* at a lower temperature than in air.

As regards the industrial application of the process, some ten to twelve tons of arsenical bismuth have already been treated in this very simple way, and it has been satisfactorily ascertained that there is no loss of bismuth by volatilisation with the arsenic.

PART V.—*The Separation of Bismuth from Antimony.*

The process hitherto adopted in practice for the separation of antimony from bismuth has usually consisted in a simple fusion at a dull-red heat with bismuth oxide or bismuth "litharge"—an operation successful enough as to its results, but one requiring no small amount of skill in manipulation; it is also one by which only small quantities can be treated readily at one time—and moreover, the temperature which is necessary to effect the separation of the antimony involves appreciable loss on account of the volatilisation of the bismuth at a red heat, notwithstanding many tens of tons of bismuth have, however, been treated under my direction by this process.

In an operation lately conducted, involving the melting of a quantity of bismuth containing about one per cent. of antimony, it was found that a peculiar oily film was noticeable rising to the surface of the melted alloy; this film did not form all over the surface of the

metal, but appeared to rise as from a boiling centre, and this although the metal was at a temperature very little above its melting point. A portion of the film or layer was removed and tested in order to ascertain its nature, and it was found to contain a very appreciable proportion of *antimony*. I, therefore, caused the operation to be continued, stirring the metal from time to time with a dried wood stirrer. In the course of three or four hours, removing the film from time to time, the surface of the melted metal assumed a much brighter appearance, and on carefully testing it at this point, the metal was found to be *absolutely free from antimony*. To confirm this and to ascertain more exactly the conditions under which this separation takes place, a further quantity of impure bismuth was operated upon in a similar manner. This second quantity contained other impurities besides antimony, its analysis being as follows:—

Bismuth, by difference	96·20
Antimony	0·80
Tellurium	0·40
Lead	2·10
Copper	0·50
Arsenic	traces
	100·00

The same simple process of fusion and stirring was again adopted —the quantity being about 350 kilogrammes—and when the same oily film commenced to rise to the surface the temperature of the molten mass of the alloy was taken by means of the Le Chatelier pyrometer. A portion of the film removed showed, on being tested, a percentage of over 30 per cent. of antimony. A slightly perceptible fume of arsenic was apparent as volatilising, so proving what I found to be the case in the separation of arsenic by simple fusion. (See *ante.*)

The point at which this separation of antimony occurs was found to be 350° C., and at this temperature the metal was maintained for about five hours.

The evidence of an oxidising action became now much less, and, although a very small amount of antimony was present, there was still a little remaining in the alloy; the temperature, therefore, was slightly raised and maintained at 458° C., as shown by the pyrometer, for about four hours, at the end of which time the bismuth became absolutely free from antimony.

The form in which the antimony separated was peculiar—a transparent glass, consisting of antimony oxide—containing about 10 per cent. of bismuth, but of course in the removal of the antimony oxide a small proportion of the bismuth was mechanically carried with it,

resulting in the production of several very interesting and very beautiful metallurgical specimens.

The great advantage of this process is, like that of the foregoing separation from arsenic, its extreme simplicity, the low temperature which renders it possible to work upon very large quantities at one time, and the very small amount of time necessary for this separation in comparison with the process hitherto adopted, and the absence of loss in the bismuth operated upon by volatilisation. It is obvious that where metals can be so easily treated in large quantities, the labour and skill hitherto necessary is very considerably reduced, and there is the additional advantage that the loss attending large operations is minimised.

In this and in my previous papers upon this beautiful metal bismuth, I have been able to point to simple dry processes for its separation from gold, lead, copper, arsenic, and antimony, and all these processes are available for treating with care large quantities at one time. When it is remembered what is involved in having to dissolve any quantity of bismuth in acids, and its subsequent precipitation from solution, it surely will be admitted that much of the difficulty in purifying crude bismuth has been effectively removed, as the methods given have been found possible in practice, and advantageous.

I have introduced upon the diagram the points at which arsenic is volatilised, and also the point at which antimony separates from bismuth under the conditions described in this paper.

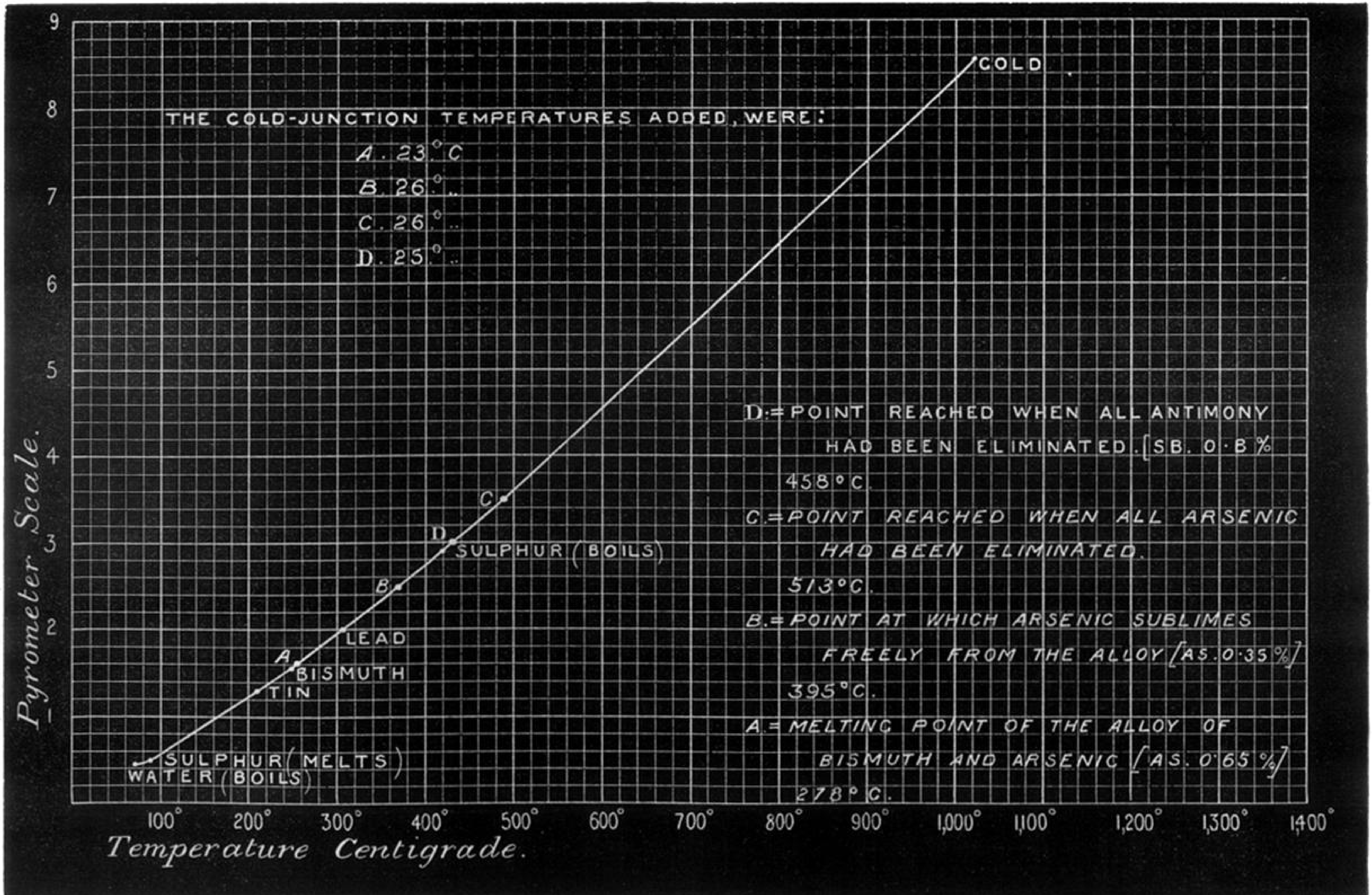
III. "On the Three-Bar Motion of Watt." By WILLIAM BRENNAND. Communicated by C. B. CLARKE, F.R.S. Received January 2, 1893.

(Abstract.)

The figure represents a simple form of "Watt's Parallel Motion." $OA = O'B = r$ are the arms that can turn freely about O,O′, fixed centres, in one plane. The link $AB = 2l$ is pivoted at A and B. As the arms move, P the middle of the link, traces out a portion of the curve, viz., from Q to Q′, backwards and forwards, nearly in a right line.

$OC = O'C = d$.—Of the three parameters d, r, l, any one can be taken as unit (in this paper l is taken 10 units); then d and r are independent parameters. The problem Watt had to solve was to discover numerical values of d and r that should give the tracing point P the smallest deviation from a right line.

Watt gave a series of values for d and r which are employed by engineers, with small thumb-rule ameliorations, to this day. They are


THE COLD-JUNCTION TEMPERATURES ADDED, WERE:
A. 23° C
B. 26° ..
C. 26° ..
D. 25° ..
COLD
C
D
SULPHUR (BOILS)
B
LEAD
A
BISMUTH
TIN
SULPHUR (MELTS)
WATER (BOILS)
D.= POINT REACHED WHEN ALL ANTIMONY HAD BEEN ELIMINATED. [SB. 0·B %
458° C.
C.= POINT REACHED WHEN ALL ARSENIC HAD BEEN ELIMINATED.
513° C.
B.= POINT AT WHICH ARSENIC SUBLIMES FREELY FROM THE ALLOY [AS. 0·35 %]
395° C.
A.= MELTING POINT OF THE ALLOY OF BISMUTH AND ARSENIC [AS. 0·65 %]
278° C.
Pyrometer Scale.
1
2
3
4
5
6
7
8
9
100°
200°
300°
400°
500°
600°
700°
800°
900°
1,000°
1,100°
1,200°
1,300°
1,400°
Temperature Centigrade.